Network Architecture…

THIS SECTION WILL FOCUS ON THE OPERATION OF NEXTEL'S DIGITAL NETWORKS

- Nextel's networks are comprised of several major elements
  - Enhanced Base Transceiver System (EBTS)
  - Base Site Controllers (BSC)
  - Dispatch Application Processor (DAP)
    - •• Home Location Register (HLR)
    - •• Visited Location Register (VLR)
  - Metro Packet Switch (MPS)
  - Mobile Switching Center (MSC)
    - •• Home Location Register (HLR)
    - •• Visited Location Register (VLR)
  - Subscriber Equipment
  - Operations and Management Center (OMC)

- This section will also highlight the manner in which Nextel's primary services are processed
  - Digital cellular interconnect
  - Direct Connect dispatch
  - Alphanumeric text messaging

THE BASIC ELEMENT OF THE NEXTEL NETWORK IS THE ENHANCED BASE TRANSCEIVER SYSTEM (EBTS) CELL SITE

- The EBTS provides the interface between mobile subscriber radios and the network equipment
  - The EBTS consists of one or more base radios, a local site controller, a radio distribution system, a frequency reference, a site synchronization receiver and antenna, a local area network (LAN) interface, and antennas
    - •• Each base radio performs the communication with the subscriber units, sending both control and compressed speech using TDMA technology
    - •• Each base radio handles one 25 KHz channel
    - •• Up to six dispatch conversations per frequency can occur simultaneously

- EBTS are configured in a cellular-like manner to enable the reuse of frequency
  - EBTS coverage areas typically vary between 1–10 miles
  - EBTS cell sites are typically configured as an omni or three-sectored site to fulfill the coverage plans of the system
    - •• Omni site configurations may include as many as 20 channels, yielding up to 120 timeslots
    - •• Sectored sites may accommodate up to 24 channels, yielding up to 144 timeslots

- The EBTS provides much of the lower level site control functions, which minimizes the number of messages sent to other infrastructure elements

- The EBTS measures call control parameters such as handover measurement request parameters

- Interconnection between the EBTS sites and other network equipment is provided through leased T1's

THE BASE SITE CONTROLLER (BSC) IS THE CONTROL AND SWITCH INTERFACE FOR ALL NEXTEL SERVICES

- The BSC provides control and concentration functions for one or more EBTS sites
  - Allocates voice traffic and control channels
  - Serves as a concentration point for up to 80 EBTS sites or 1600 base radios
  - Performs handovers between multiple EBTS under its control
  - Provides a concentration point for the operations and network management system

- Each time a Nextel subscriber places an interconnect, dispatch, or text message communication, the transmission is sent through the BSC
  - Switches EBTS sites to mobile switching center for cellular calls
  - Switches EBTS sites to dispatch application processor/metro packet switch for direct connect calls

- The BSC and mobile switching center are connected by redundant 24 channel leased T1's

- The BSC exchanges signaling information with the MSC through an "A" interface based on GSM that has been modified to support iDEN radio requirements; this includes changes in message formatting and inclusion of additional parameters for handover messaging

DISPATCH APPLICATION PROCESSORS AND METRO PACKET SWITCHES ARE RESPONSIBLE FOR THE OPERATION OF DIRECT CONNECT DISPATCH COMMUNICATIONS

- The Dispatch Application Processor coordinates and controls the Direct Connect dispatch service
    - Processes Private, Group, and Alert Calls
    - Contains subscriber data on individual fleet and unit information, dispatch and ID features, subscriber talkgroup information, and a unit's calling privileges

- The DAP also registers and deactivates subscriber units
    - Provides over-the-air subscriber configuration (system parameters)
    - Provides auto-registration
    - Provides push-to-talk ID

- When a subscriber unit is turned on, its identification and location are automatically registered at the DAP and tracked until the unit is turned off

- The DAP conserves radio frequency (RF) resources by selectively illuminating only those EBTS sites where there are subscribers in a particular talkgroup

- The Nextel network has 15 DAPs nationwide

- The Metro Packet Switch (MPS) consists of a packet switch and packet duplicator and enables wide-area Direct Connect service
    - Replicates and distributes dispatch voice packets
    - Provides a concentration point for multiple BSCs
    - Provides traffic control allocation

- The MPS voice packet protocol is based on frame relay technology

THE MOBILE SWITCHING CENTER (MSC) PROVIDES THE INTERFACE BETWEEN THE NEXTEL NETWORK AND THE PUBLIC SWITCHED TELEPHONE NETWORK

- A Nortel digital multiplex switch provides a variety of services to Nextel users within a certain geographic coverage area at the MSC
  - Authentication of subscriber units
  - Processes all cellular calls
  - Provisions supplementary subscriber services and features
  - Controls call setup and routing procedures
  - Collects and routes billing and statistical information
  - Controls handoffs between EBTS controlled by different BSCs
  - Controls roaming between MSCs

- Messages between MSCs rely on a proprietary Motorola protocol not the cellular IS-41 protocol

- The MSC and BSC are linked by T1 facilities using mu-law protocol

- Nextel has 22 Nortel DMS switches serving as MSCs and plans to have 35 installed by the end of 1998

- A Message Mail Service (MMS) is attached to the MSC and encompasses all the hardware and software required to store and deliver alphanumeric text messages

HOME LOCATION AND VISITED LOCATION REGISTERS LOCATED AT THE DAP AND MSC TRACK AND VALIDATE NEXTEL USERS

- The DAP home location registers (D-HLR) are databases residing in the DAP that store information on dispatch access rights and features specific to each phone
    - Perform subscriber access control and is queried each time a dispatch call is initiated
    - Manage access to the system by verifying requests for service against a database of subscriber privileges

- The MSC home location register (M-HLR) store every phone's permanent subscriber interconnect record
    - Phone IDs and various telephone supplementary services are provisioned in the M-HLR
    - Performs subscriber access control
    - Queried each time an interconnect call is initiated or call feature is requested

- The Visited Location Registers are fast access RAM databases at the MSCs and DAPs that contain real-time information on each subscriber unit (i.e., location within the system) as well as feature provisioning information found in the HLRs

NEXTEL PHONES ARE INCOMPATIBLE WITH ANY OTHER WIRELESS NETWORK AND FOLLOW A REGISTRATION PROCESS EACH TIME THEY ARE POWERED-ON OR MOVE FROM ONE EBTS SITE TO ANOTHER

- When phones are shipped from the Motorola factory, they do not require programming by Nextel or a dealer
    - System access is denied until arrangements are made with Nextel to authorize the phone on the network
    - Each phone has a version of code software, a control channel band map, and an International Mobile Equipment Identifier (IMEI)
    - The IMEI and its associated configuration parameters must be entered into the MSC and DAP HLRs before the phone can access the network

- A phone will attempt to register with the system when it is first turned on
    - During this registration attempt, the phone sends the IMEI to the D-HLR and M-HLR and then an International Mobile Subscriber Identity (IMSI) that uniquely identifies the unit on the system is assigned, the operating parameters are downloaded, and access to the network is allowed
    - The IMSI is also sent to the VLR
    - The IMEI is used in this initial system access request only and never again

- Phones are registered in a different manner subsequent to the initial registration
    - After a unit is powered on it sends its IMSI to the MSC HLR which issues and sends a temporary mobile station identifier (TMSI) to the phone
    - The TMSI is also sent to the VLR
    - The TMSI may be changed between calls or even during a call to preserve subscriber confidentiality

NEXTEL'S ENTIRE NETWORK IS MANAGED AT THE OPERATIONS AND MANAGEMENT CENTER IN MCLEAN, VIRGINIA

- The OMC is connected to other system elements through a X.25 packet network

- The OMC supports several key functions
  - Configuration management (i.e., software loads, databases maintenance, and component status monitoring)
  - Fault management (e.g., diagnostics and loop-back tests)
  - Performance management (i.e., collection and synthesis of metrics)
  - Security management
  - Event/alarm management

- System reports are generated and system performance can be measure at the OMC

NEXTEL DIGITAL INTERCONNECT CALLS ARE PROCESSED SIMILAR TO OTHER WIRELESS SERVICE CALLS

- All outgoing Nextel telephone interconnect calls are processed by the service area's MSC
  - A Nextel subscriber dials a telephone number
  - The call request is sent via control channel to the nearest EBTS
  - The EBTS sends control information and call content to the BSC
  - The MSC processes the authentication procedure (if necessary), processes dialed digits, communicates with the PSTN (for landline calls only), and provides call routing instructions and a radio channel pair to the BSC and mobile station
  - Assuming authentication and landline call completion, the MSC sends a connecting message to the subscriber unit

- Incoming interconnect calls are also handled by the MSC
  - The MSC processes an incoming call from the PSTN by searching for the last known location of the called mobile and then sending a page to the BSC in that area
  - If the mobile station is powered on, it acknowledges the page via the control channel and requests a radio channel
  - The MSC provides routing instructions and a radio channel pair to the BSC and called subscriber (subscriber-to-subscriber calls are directly connected between BSCs)
  - The MSC connects the call through to the mobile station for ring alerting; upon call answer, the voice connection is established
  - If busy, the calling party is sent a busy tone
  - If no answer, the call is terminated with a no answer message unless alternative call answering is applicable (voice mail or call forwarding)

A DIRECT CONNECT DISPATCH CALL IS INITIATED WHEN A USER PUSHES THE PTT BUTTON FOR A PRIVATE OR GROUP CALL

- Dispatch call requests are immediately routed by the EBTS to the DAP

- The DAP determines and validates the caller's talk group during group call requests and identifies the locations of the group mobiles (if needed, the DAP sends a base station location request for the location area of each mobile station in the talk group)

- The DAP provides the requesting EBTS with a radio channel and routing information for the caller's voice packets – the DAP also provides radio channels for the destination EBTS and mobile stations in the talk group

- If a radio channel is not available at the EBTS of one or more other talk group members, those members are included in the call when a channel becomes available at their serving EBTS

- The iDEN system employs a hang timer that allows a subscriber to continue a Direct Connect conversation without the need to set up another channel
    - Dispatch users typically learn the habit of releasing the PTT microphone button at the end of each spoken phrase to await a response
    - If the conversation continues, it will usually occur within several seconds
    - The hang timer can be adjusted by a system operator to reduce the average traffic intensity

TEXT MESSAGING AND ALPHANUMERIC PAGING IS PROVISIONED IN THE IDEN NETWORK THROUGH THE MESSAGE MAIL SYSTEM

- Text messages generated by software on the Internet, dual-tone multifrequency (DTMF) dialed digits within the MSC, or voice mail notification stored in a home location register are processed and forwarded by the MMS to the MSC

- If a message is waiting or stored for the mobile and the mobile is idle (powered on but not in use) or on an interconnect call, the MMS will deliver the message to the MSC through interface software

- The MSC routes the message data to the BSC and EBTS where the radio is located for delivery over the control channel to the radio

- A feature of iDEN or cellular/PCS based messaging is the handset's ability to acknowledge receipt of messages by transmitting an acknowledgment signal via the EBTS back to the MSC and MMS

- The network also allows radios to generate and transmit messages to the MSS over the control channel for forwarding to other mobiles and networks via the BSC and MSC